

ULTRASONIC ANGIOLOGY DEPARTMENT

Document Detail		
Document Type		Standard Operating Procedure
Vascular protocol		Lower Limb Arterial Duplex Evaluation
Document location		Ultrasonic Angiology Department (GSTT)
Version		4.0
Effective from		August 2017
Review date		August 2018
Owner		Soundrie Padayachee, Consultant
Author		Beth Sreeves, Clinical Vascular Ultrasound Scientist
Approved by, date		Andrew Arnold, Principal Clinical Scientist Date: December 2019
Superseded documents		LLA SOP, January 2013
Related documents		<ul style="list-style-type: none">• LLA Pathways• Clinical Pathways• Local pathways• Reporting SOP
Keywords		LLA, Lower Limb Arterial Duplex
Relevant external law, regulation, standards		<ul style="list-style-type: none">• NSHCS• VS• SVU• SVT• BMUS• IPEM
Change History		
Date	Change details, since approval	Approved by

PURPOSE

Lower Limb Arterial (LLA) disease typically results from atherosclerotic occlusion, however other causes include trauma, arteritis and arterial entrapments¹.

Ultrasonography of the lower limb arteries (from Aorta to ankle) can determine the presence, severity and location of arterial disease (both occlusive and aneurysmal). This information may be used to monitor disease progression, plan future treatments (for example, angioplasty, stenting or bypass surgery), or determine the success of previous treatments.

COMMON INDICATIONS

Some of the common indications for LLA evaluation:

- Symptomatic LLA disease, for example:
 - Intermittent claudication²
 - Chronic critical limb ischemia typified by chronic rest pain, ulcers or gangrene²
 - Acute limb ischemia typified by pain, pulselessness, pallor, paresthesia and paralysis²
- Pre-intervention, to plan treatment options
- Post-intervention, for example to assess angioplasty and stenting success
- Physician unable to palpate pulses during a clinical assessment³
- Physician palpates a LLA aneurysm during a clinical assessment³
- Monitor disease progression
- Determine presence of lower limb arterial disease prior to compression bandaging for venous ulcers

CONTRAINDICATIONS AND LIMITATIONS

Contraindications and limitations for LLA evaluation include:

- Patient discomfort (for example, severe rest pain when leg elevated) may mean the scan cannot be tolerated
- Patient obesity, patient position, presence of stoma bags, and lower leg ulceration and dressings may limit visualisation of the lower limb arteries

PATIENT COMMUNICATION**The Vascular Scientist should:**

- Call the patient in from the waiting room and show them to the scanning bay
- Introduce self to the patient and explain the purpose of the exam performed and indicate the typical length of the exam
- Explain the procedure to the patient to ensure that the patient understands the necessity for each aspect of the evaluation
- Obtain verbal consent for the examination
- Respond to questions and concerns about any aspect of the examination
- Educate patient about risk factors and symptoms of LLA disease
- Refer patient's specific questions regarding diagnosis, treatment or prognosis to their physician
- Inform the patient when the scan has finished, and explain that the images will be reviewed and a report produced for their consultant

PATIENT ASSESSMENT AND PHYSICAL EXAMINATION**The Vascular Scientist should:**

Patient assessment must be performed before the LLA imaging. This includes assessment of the patient's ability to tolerate the procedure and an evaluation of any contraindications to the procedure.

Obtain and record on the scribble sheet a complete, pertinent history by interview and/or review of the patient's medical record. A pertinent history includes:

- Current medical status
- Presence of any signs or symptoms of LLA, including claudication location and distance and presence of rest pain or gangrene
- Relevant risk factors for LLA disease including diabetes, hypertension, age, gender and smoking status³
- Relevant medications or therapies
- Results and types of prior vascular procedures, interventions and prior studies when available

All consultations must be made and documented in accordance with the relevant trust policies, for example promoting dignity and respect, maintaining patient confidentiality and writing in patient records.

PATIENT POSITIONING

Position the patient supine on the scanning couch. Patient should remove their shoes, socks and trousers, and will need to lift their shirt to expose their abdomen during the Aorta and iliac artery assessment. Patient may lie prone for popliteal artery (POP), TP-trunk and peroneal artery assessment. Examiner should be as close to the examined extremity as possible to allow for ergonomically sound scanning.

INSTRUMENTATION

Utilize appropriate ultrasound instrumentation (for example a Philips IU22, EPIQ7 or CX50 ultrasound systems), with appropriate frequencies for the vessels being examined.

- Typically, a linear array (for example L9-3 MHz) to visualise the femoral, popliteal and tibial arteries, a curved array (for example C5-1 MHz) may be used in larger patients
- Typically, a curved array (for example C5-1 MHz) should be utilized to visualise the aorta and iliac arteries

EXAM PROTOCOL

Throughout each examination the Vascular Scientist should:

- Observe the sonographic characteristics of normal and abnormal blood vessels, and allow the necessary adjustment to optimize exam quality
- Assess and monitor the patient's physical and mental status, allowing modifications to the procedure plan according to the patient's clinical status
- Analyse sonographic findings to ensure that sufficient data is provided to the physician to direct patient management and render a final diagnosis
- Follow a standard exam protocol for each segment evaluated

Ankle Brachial Pressure Index (ABPI) assessment:

- Record the ABPI according to the ABPI SOP

LLA duplex assessment:

- Starting at the inguinal ligament, image the CFA in longitudinal view
- Identify the Superficial Femoral Artery (SFA)/Profunda artery origin bifurcation
- Track the SFA from origin to knee
- Image the POP, tracking the artery distally to the TP-trunk
- Track the peroneal, Anterior Tibial Artery (ATA) and Posterior Tibial Artery (PTA)
- Image the External Iliac Artery (EIA), tracking the artery proximally to the Common Iliac Artery (CIA) and aorta

Digitally store static images during the assessment. Minimum image requirements: Longitudinal view duplex ultrasound images including spectral Doppler waveforms with Peak Systolic Velocity (PSV) measurements from:

- Aorta
 - CIA
 - EIA
 - CFA
 - Profunda artery origin
 - SFA at origin, mid-thigh and knee
 - POP above and below knee
 - TP-trunk
 - PER - proximal, mid and distal
 - ATA - proximal, mid and distal
 - PTA - proximal, mid and distal
- Transverse view B-mode images:
- Aorta maximum diameter using calipers positioned on the anterior and posterior artery walls, measuring from leading edge to leading edge⁴ at peak systole²

B-Mode imaging:

- Optimise the B-Mode image, including appropriate adjustment of time gain compensation, zoom and depth

- Identify occlusive disease appearance
 - Homogenous occlusion with low echogenicity indicative of fresh thrombus²
 - Heterogeneous occlusion with strong echoes indicative of old non-uniform calcified areas of atheroma²
 - Artery wall thickening indicative of a vascular arteritis⁵
- Identify dissections, aneurysmal disease and previous interventions, including stents and endarterectomy

Colour flow imaging:

- Optimise the Colour flow image, including appropriate adjustment of scale and colour box size
- Identify the direction of blood flow, stenotic flow (through aliasing), presence/absence of flow, dissections and prominent collateral vessels

Spectral Doppler:

- Optimise the spectral Doppler trace, including appropriate adjustment of scale and gain
- Ensure the Doppler angle is correctly aligned to the blood flow and $<60^\circ$
- Identify the direction of blood flow and presence/absence of flow
- Identify stenotic flow through PSV measurements, recording the maximum PSV at the point of narrowing
- Record a reference PSV in the normal artery proximal to the stenosis
 - in the instance where a proximal value is not available (such as an origin stenosis), use a normal distal PSV (note, may overestimate stenosis due to effect of the stenosis).
- Record 2 PSV values for areas of focal interest

Equation to grade stenotic disease:

$$\text{Stenosis (\%)} = 100 \times (1 - \text{PSVp}/\text{PSVs})^*$$

PSVp = PSV proximal to the stenosis

PSVs = maximum PSV at the point of stenosis

*Stenosis equation modified from Cossman⁶

Waveform Shape analysis should be employed to assist in disease interpretation.

- Normal lower limb arterial waveforms should be triphasic with a clear spectral window.
- Biphasic waveform and a shoulder on the down stroke of the waveform suggests significant distal stenosis/occlusion
- Damped, monophasic waveforms suggest severe stenosis/occlusion proximal to the sonogram.

This is formalised in the table below.

Classification	Features
Normal	<ul style="list-style-type: none"> • Triphasic waveform with a systolic forward flow, a short reverse flow component followed by a diastolic forward flow • Biphasic waveform with only one forward and reverse flow component may be found in the elderly • Narrow spectral band throughout the pulse cycle
1-19% diameter reduction (wall irregularities)	<ul style="list-style-type: none"> • Normal PSVs and waveform contour • Spectral broadening • Normal waveforms proximally and distally to area involved
20-49% diameter reduction	<ul style="list-style-type: none"> • Reverse flow component maintained • PSV increased by >30% compared to proximal recording site • Marked spectral broadening • Flow patterns at the proximal and distal recording sites unchanged
50-99% diameter reduction	<ul style="list-style-type: none"> • Loss of reverse flow with forward flow during the entire heart cycle (monophasic waveform) • PSV increase marked (>100%) • Extensive spectral broadening • Waveform proximal to the stenosis is affected only when the lesion is >80% in terms of diameter reduction • Abnormal distal waveform

Occlusion	<ul style="list-style-type: none"> • No flow is detected • Flow patterns, both proximal and distal to the occlusion, are disturbed
-----------	--

Criteria for classifying lower limb arterial disease based on spectral Doppler waveform analysis⁷

REVIEW OF THE DIAGNOSTIC EXAM FINDINGS

The Vascular Scientist should:

- Review data acquired during the LLA examination to ensure that a complete and comprehensive evaluation has been performed and documented.
- Explain and document any exceptions to the routine LLA Examination protocol (for example, study omissions or revisions).
- Before the patient leaves the department, alert the referring clinician & Head of Department when immediate attention is indicated.

PRESENTATION OF FINDINGS

The Vascular Scientist should:

- Write and complete a report based on the findings, according to the reporting SOP.
- Provide preliminary results directly to the clinical team on LLA examination findings if required.
- Present record of diagnostic images, velocity spectral data and explanations for suboptimal exams.
- Provide information of changes from previous scans and any interventions if on a surveillance programme.

EXAM TIME RECOMMENDATIONS

High quality accurate results are fundamental elements of LLA evaluation. A combination of indirect and direct examination components is the foundation for maximizing exam quality and accuracy. For a unilateral scan, recommended time for indirect examination components is 10 minutes and for direct examination components is 20 minutes. For a bilateral scan,

recommended time for indirect examination components is 15 minutes and for direct examination components is 45 minutes.

Indirect examination components include:

Pre-examination activities

- Initiating examination and paperwork
- Equipment and examination room preparation - bay should be prepared, ensuring clean linen and transducers, white roll, gel and any equipment required are present
- Patient communication
- Patient assessment
- Patient positioning

Post-examination activities

- Examination room clean-up - bay should be prepared for the next patient, ensuring clean linen and transducers, white roll, gel and any equipment required are present
- Review of the diagnostic examination findings
- Processing of the examination data for preliminary reporting and/or final interpretation

Direct examination components include:

- Equipment optimization
- Hands-on, examination process

All scans should be reviewed and reported within the same session in which they are performed to minimise delays.

Urgent Referral

If immediate attention is indicated, alert the Vascular team & Head of Department before the patient leaves the department, for example if:

- There is significant disease progression (occlusion/stenosis $\geq 70\%$) in a stent or at an endarterectomy site
- Fresh occlusive thrombus is identified
- The patient has acute limb ischemia
- The patient has chronic critical limb-ischemia with rest pain
- A new lower limb aneurysm ($\geq 3.0\text{cm}$) or Abdominal Aortic Aneurysm ($\geq 5.5\text{cm}$) is identified

REFERENCES

1. Golledge J, Lower-limb arterial disease. Lancet 1997; 350: 1459-1465
2. Thrush A and Hartshorne T, Vascular Ultrasound: How, Why and When, Third Edition, 2010, New York: Churchill Livingstone
3. Norgren L et al., Inter-Society Consensus for the Management of Peripheral Arterial Disease (TASC II). European Journal of Vascular and Endovascular Surgery 2007; 33: S1S70
4. Gurtelschmid M et al., Comparison of Three Ultrasound Methods of Measuring the Diameter of the Abdominal Aorta. The British Journal of Surgery 2014; 101: 633-636
5. Raninen R O et al., Arterial Wall Thickness Measurements by B Mode Ultrasonography in Patients with Takayasu's Arteritis. Annals of the Rheumatic Diseases 1996; 55: 461-465
6. Cossman D V et al., Comparison of contrast arteriography to arterial mapping with Colour-flow Duplex Imaging in the Lower Extremities. Surg. 1989;10;522-9
7. Jager K A et al., Noninvasive mapping of lower limb arterial lesions. Ultrasound in Medicine and Biology 1985; 11: 515-521